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Infrastructure Assessment Methodology

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Purpose

- Present results from USMA infrastructure assessment research team's study
- Propose direction for future research

Outline

- Introduction
  - Background
  - Bottom Line Up Front (BLUF)
  - Problem Definition Phase
  - Ongoing infrastructure-related research
- Methodology
  - Hierarchy
  - Mathematical Model Formulation
- Recommendations for Future Research

Background (1 of 2)

- Typical Scenario
  1. Unit alerted for deployment
  2. Begin planning and preparations for particular operation:
     - Combat operations in the contemporary operating environment (COE)
     - Support Operation
  3. What assets are needed in the area of operations? When will these assets be needed? Availability of assets? Etc.
     - Planning tools and processes were adequate for traditional missions;
     - Not adequate for missions in COE (e.g. infrastructure renewal);
     - Why is IA important? Must also focus on satisfying [Maslowe's] basic needs – 'ours' and 'theirs' (Wilson, et. al.), in order to 'win' GWOT;
     - Unfortunately, "We" have lacked institutional knowledge and technical background, and hence, have failed to allocate enough time in the planning process to effectively plan and execute tasks that are not directly related to combat operations.

Background (2 of 2)

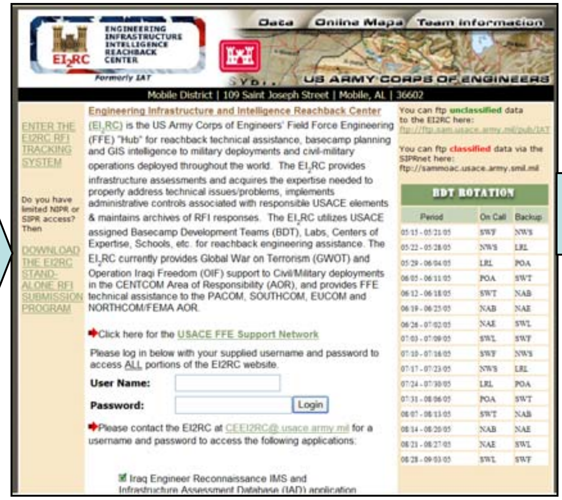
- *(Nov/ Dec 2004)* COL Joe Manous received request from LTC Thomas Magness (Chief Engineer Observer-Controller (O/C) at the National Training Center (NTC))
  - Have we [i.e. institutions responsible for developing, teaching, and validating Army engineer doctrine] identified the right infrastructure categories?
  - Can you [West Point] create a tool that will help commanders assess infrastructure on the ground?
- This request was echoed by the U.S. Army Engineer School
  - Contract to develop “checklists” to support this assessment effort was awarded to the Construction Engineering Research Lab (CERL);
  - Checklists built on work previously done by COL Welch’s cadets;
  - Reachback center out of USACE’s Mobile District did a great job of reaching out to rest of military engineer community for this endeavor.

http://www.wood.army.mil/eschool/

http://www.irwin.army.mil/Units/Operations%20Group/Sidewinder/default.htm

Bottom Line Up Front

1. Infrastructure Recon/ assessment applications with data collection and dissemination capabilities already exist.



http://gis.sam.usace.army.mil/iat.asp

$$V(x) = \sum_{i=1}^{n} w_i v_i(x_i)$$

2. Use the data available to produce a prioritized list of critical infrastructure for decision makers.

Minimize (or Maximize) $\sum_{j=1}^{n} c_j x_j$

Subject to $\sum_{j=1}^{n} a_{ij} x_j \geq b_i$

3. Use prioritized list to develop a mathematical model that will help allocate infrastructure renewal assets to selected locations.

Problem Definition Phase

- Develop Value Hierarchy
- Design Considerations
- Problem Statement

Initial Value Hierarchy

Desired Endstate

Promote self-sufficiency of affected country or region

Minimize amount of time U.S. and/ or coalition forces are on the ground of a sovereign nation

Ensure that conditions are “sufficient” to promote “benevolent form of government”.

Design Considerations

- Flexible, adaptable, scalable in order to be used on contingency ops worldwide.
- Can be used by non-engineers (e.g. Civil affairs, scouts (11B/ 19D)).
- Needs to provide some quantifiable evaluation of an area's infrastructure status.
- Needs to account for threat (e.g. insurgent or conventional forces) status.
- Eventually automated to be integrated w/ GIS and other IA data & tools.
- Need to consider educating users:
  - Via illustrations/ images;
  - Describe how to take measurements;
  - Describe what to take pictures of.
- Allow for rapid high value asset assessment

Problem Statement

Develop an infrastructure assessment methodology that facilitates the allocation of infrastructure renewal resources within a particular region in order to foster a climate within a country or region that promotes the self-sufficiency of the affected country or region.

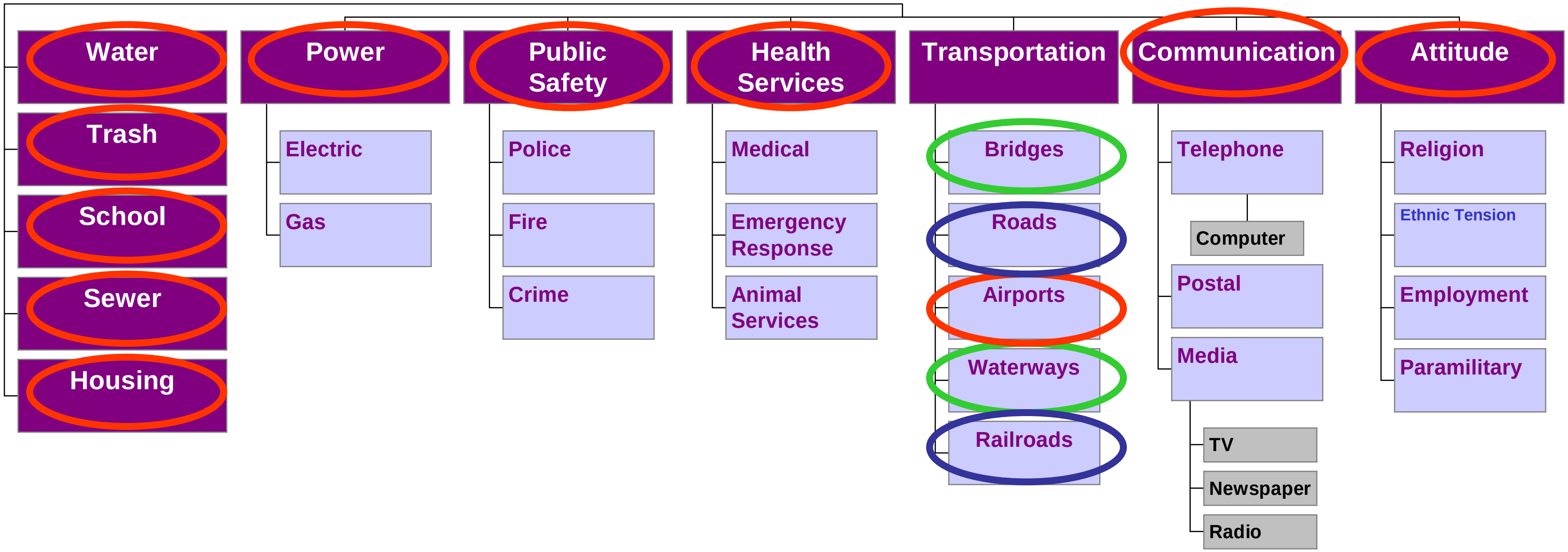
Ongoing Research

- **Contemporary research efforts** are centered around domestic infrastructure assessment and security
  - Large portion of university dollars appear to be focused on influencing domestic policy via Department of Homeland Defense
    - "What infrastructure is truly critical [ID] and how do we ensure [the majority of] the critical systems are functional following an isolated, catastrophic incident, while minimizing the expenditure of resources [act])?"
  - Much of it is in the risk management field
    - International Journal of Critical Infrastructure http://inderscience.metapress.com/link.asp?id=110843
  - Primary references
    - National Strategy for the Physical Protection of Critical Infrastructures and Key Assets;
    - CRS Report for Congress, *Critical Infrastructure and Key Assets: Definition and Identification*, 1 October 2004.
- **Our focus –** Theater of Operations (TO) infrastructure security, assessment, and repair (re-build)
  - Dr. Greg Parnell (USMA) recommended that we use the existing literature and related resources and methodology as the foundation for our research;
- Can the same techniques and methodologies be used for both domestic AND theater of operations (TO) infrastructure assessment?

Our Observations

- We already do a great job of gathering and storing the information
  - Software solutions, managed by the Engineering Infrastructure Intelligence Reachback Center (EI2RC), are widely used and readily available.
- However, infrastructure prioritization efforts and subsequent resource allocation efforts still fall short of desired outcomes when it comes to theater of operations (TO) infrastructure. We hope to overcome this by:
  - Developing infrastructure hierarchy for value model;
  - Formulating a mathematical (optimization) model to help determine resource allocation.
- Key assumptions:
  - Methodology used for homeland defense can be applied in non-domestic infrastructure renewal and security scenarios.
  - We have already properly categorized the different aspects of "infrastructure";

Engineer School “Infrastructure” Categories



A total of 13 categories (or systems) – all have been incorporated into EI2RC automated tools.

Categories circled with blue & green circles are combined into one infrastructure category.

Typical Scenario – Re-visited

1. Unit alerted for deployment
2. Begin planning and preparations for particular operation
3. What assets are needed in the area of operations? When will these assets be needed? Availability of assets? Etc.
4. Deploy
   - Combat operations (i.e. disrupting/ eliminating the enemy)
   - Support operations (as part of SASO) (e.g. facilitate elections, repair power plants, giving away frozen chickens, etc.)
5. Observe, Orient, Decide, Act (OODA) *(COL John Boyd, USAF(Ret))*
   - EI2RC is a way by which we can help orient.

Observe

- Hand-held capture devices for troops;
- Tablets & docking stations for Forward Engineering Support Teams (FEST);
- Transmitted to Reachback Center in Mobile.

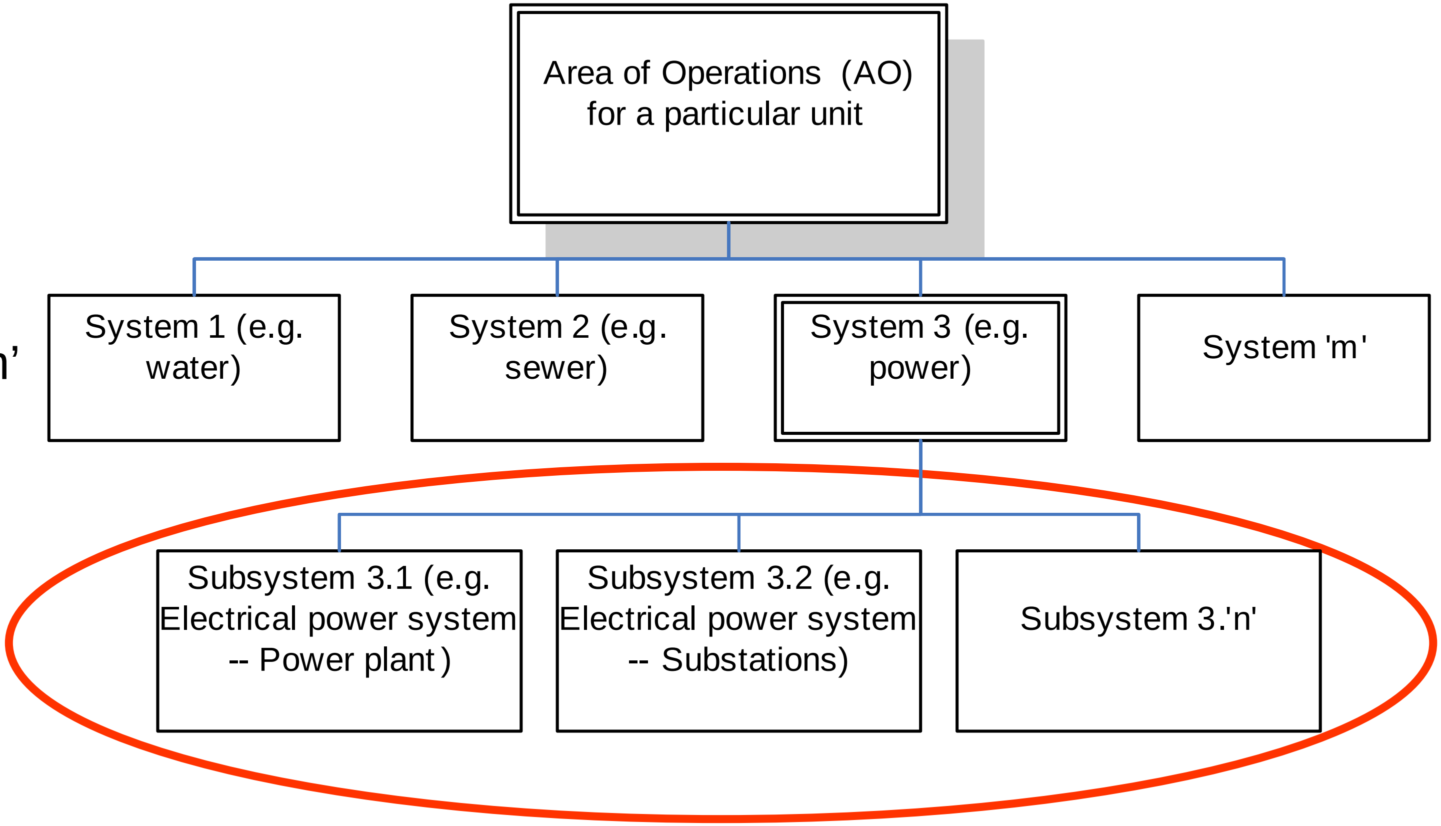
   - But what tool supports our ability to decide and act?

Functional Hierarchy

Begin the assessment at the lowest level

Systems 1, 2, …, ‘m’

Subsystems 1, 2, …, ‘n’



Evaluation Measures

- 11 evaluation measures *(determined for every sub-system)*
  1. Population served *(Higher is more critical)*
  2. Cost to repair or replace *(Less is better)*
  3. Amount of time until assessment can be completed *(Less is better)*
  4. Amount of time needed to repair or replace *(Less is better)*
  5. Current "perceived" degradation in level of service (LOS) (% change from 'original' LOS) *(Higher is more critical)*
  6. Number of U.S. or coalition personnel needed to secure until operational or until host nation can provide adequate security *(Less is better)*
  7. Amount of time needed to secure *(Less is better)*
  8. Number of identical (or nearly identical) subsystems currently available to perform same (or very similar) level of service at the same location *(Less is better)*
  9. # of other subsystems 'immediately' dependent on this subsystem to operate properly *(Higher is more critical)*
  10. # of incidents (related to enemy activity) per capita *(Less is better)*
  11. Income per capita *(Higher is more critical)*

Method of Assessment (1 of 5)

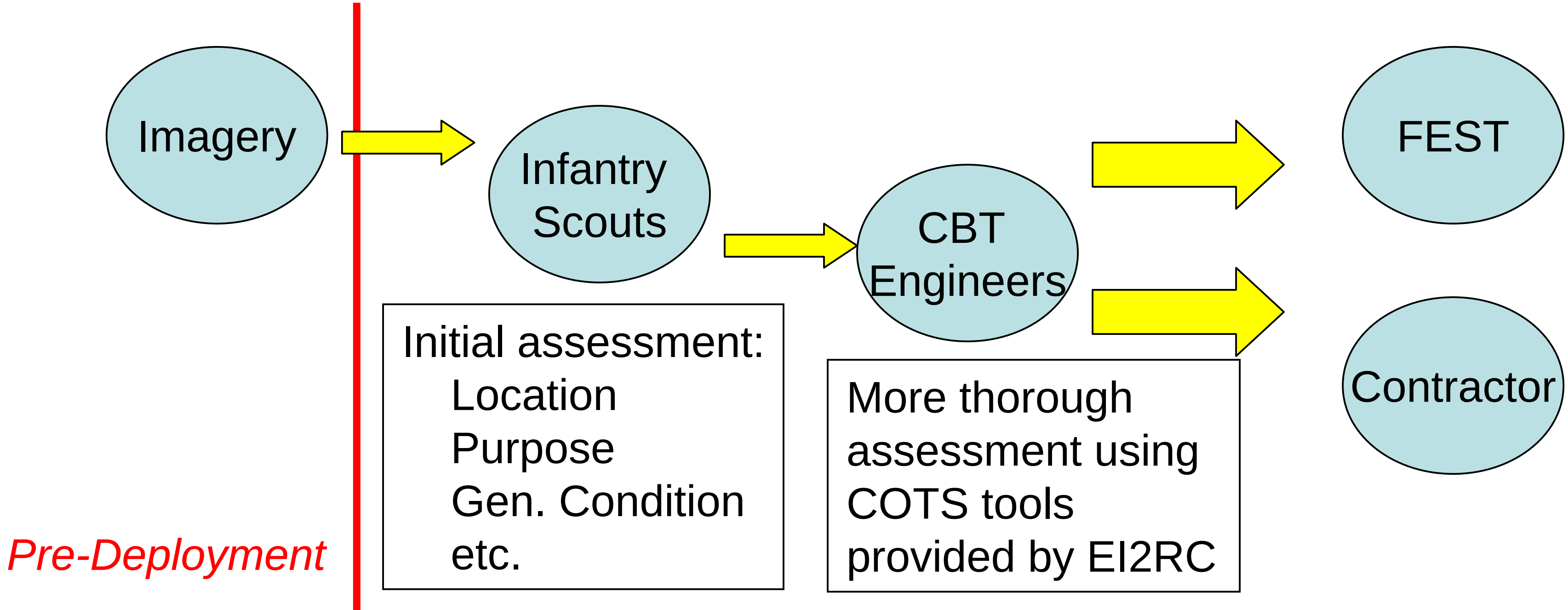
- **Endstate:** Develop a prioritized list of infrastructure subsystems (e.g. water pumps, electrical power generation facilities, etc.) so that the commander can make an informed decision about how to best allocate infrastructure renewal resources.
- The overall level of importance of an infrastructure subsystem is the sum product of the raw value scores and the global weights of the evaluation measures:

$$V(x) = \sum_{i=1}^{p} w_i v_i(x_i)$$

- Obtain raw value scores $v_i(x_i)$ for each of these evaluation measures using data provided by existing software solutions (EI2RC) via 'boots on the ground'.
- Obtain (global) weights w_i using the swing-weighting method (Kirkwood)

Method of Assessment (2 of 5)

- How do I obtain value scores $v_i(x_i)$ for each of these evaluation measures? Example:

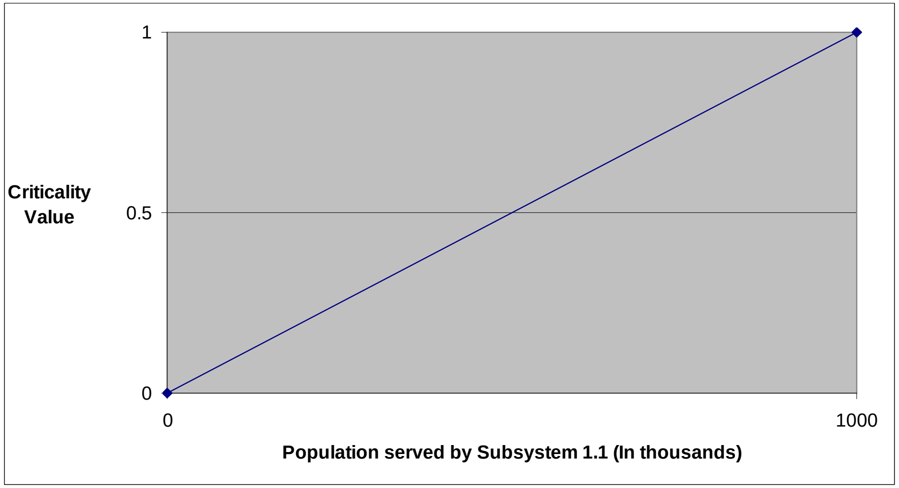


Constantly gathering data & asking the question: Does this (infrastructure) subsystem need to be secured, assessed, &/ or repaired (rebuilt)?

Method of Assessment (3 of 5)

- Assume Subsystem 1.1 represents:
  - System 1 (Water)
  - Subsystem 1 (Pumps)
- Definition:
  - Total number of people served by a particular subsystem at a particular location (Higher is more critical)
- Global Weight:
  - Varies by user input *(see demo)*
- Type:
  - Direct measure, Natural
- Value Curve:
  - Linear

Raw data is entered into value function in order to obtain a score $v_i(x_i)$ between 0 and 1.



Method of Assessment (4 of 5)

- Hypothetical example, Hydroelectric dam
  1. Provides power to 1,000,000 people (Value function = 1)
  2. Requires one small, inexpensive component to restore to 100% generating capability (Value function = 1)
  3. Expert is on hand to complete a five-minute assessment (Value function = 1)
  4. Takes five minutes to repair once assessment is complete (Value function = 1)
  5. Current capability is 0% of expected level of service (100% degradation from LOS) (Value function = 1)
  6. Doesn't take any soldiers to secure until operational (Value function = 1)
  7. As soon as it is repaired, further security not required (Value function = 1)
  8. There are zero subsystems that can provide anywhere close to the generating capacity to the affected population (Value function = 1)
  9. Fifty other subsystems (to include subsystems at multiple locations) are dependent on this hydroelectric dam (Value function = 1)
  10. Zero enemy incidents per person over the last week (Value function = 1)
  11. Per capita income of population served by this subsystem is $100K (Value function = 1)

Method of Assessment (5 of 5)

- How do I obtain global weights w_i for each of these evaluation measures?
- We assume that the weight w_i of an evaluation measure is based on two things:
  - Level of Importance (Obtained by using weighted average of subject matter expert input)
  - Amount of variation between an evaluation measure and a hypothetical, worst-case scenario: Swing weighting method (Kirkwood)

GLOBAL WEIGHT ASSESSMENT TABLE							
		Level of Importance of the Evaluation Measure					
		Critical Factor		Important Factor		Factor	
Variation in Measure Data	High	Electrical power generation_# of dependent subsystems					
	Medium						
	Low	Water pump_population served				Government facility_population served	

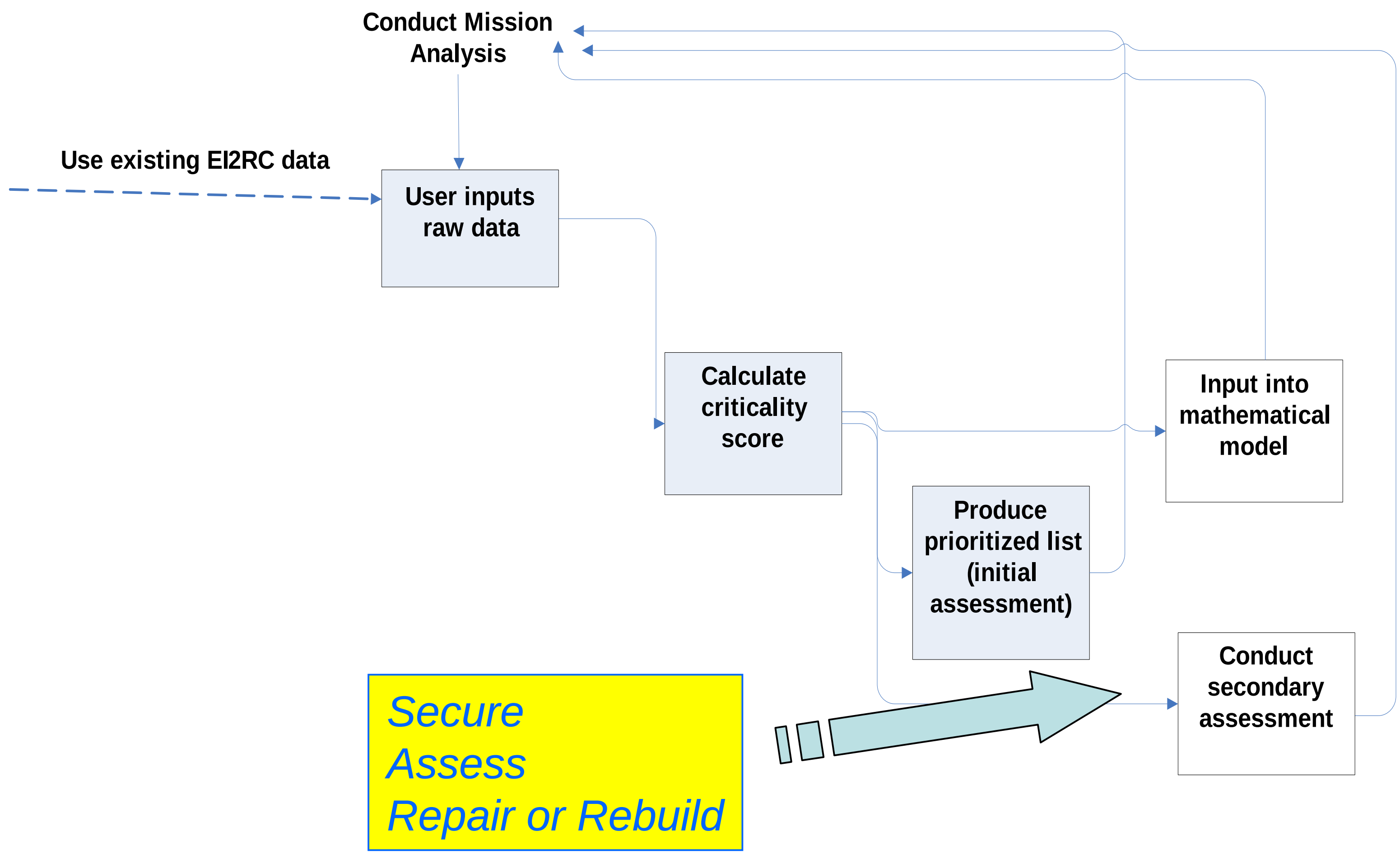
Method of Assessment: Summary

- The overall level of importance of an infrastructure subsystem is the sum product of the raw value scores and the global weights of the evaluation measures:

$$V(x) = \sum_{i=1}^{p} w_i v_i(x_i) \qquad \sum_{i=1}^{n} w_i = 1$$

- Where *x* is a subsystem, x_i=score of the subsystem on the i^{th} evaluation measure, $v_i(x_i)$= criticality of the subsystem on the i^{th} measure, *V(x)* is the overall criticality of the subsystem and *p* = total number of evaluation measures for sub-system *x* (*p* is a subset of *n*).
- The sum of the global weights of the evaluation measures across all subsystems (a total of *n* measures) for every location must equal one for the additive properties of utility theory to hold true.
- Each of the subsystems are then prioritized by their criticality value *V(x)* and arrayed in a list.

Flow Diagram



Mathematical Model

- Now that we have a prioritized list of infrastructure missions, how do we allocate units (via modules) to the missions?
- More specifically:
  – How do we complete infrastructure renewal missions as quickly as possible while minimizing the “cost” of allocating infrastructure renewal assets to a subset of missions?

Applicable Background

- Army Transformation
  - "Modularize" our units
  - Reduce number of unneeded assets (i.e. headquarters) in theater
  - "Plug & play"
- Director of Combat Developments for each branch developed module concepts
- What if we mapped module capabilities to mission requirements within our software and planning tools?
  - Example of capability: Horizontal construction module (may be a platoon) can build 3 km of road a day
  - Example of requirement: City of Baghdad requires 50 km of road_rebuild construction effort

Objective Function

- Minimize

$$\sum_{t}\sum_{r} a_{tr} \sum_{m} x_{trm} + \sum_{r}\sum_{m} q_{rm} v_{rm} + \sum_{m} s_{m} (\mathrm{max\_v}_{\mathrm{m}} - \mathrm{min\_v}_{\mathrm{m}})$$

X_{trm} = 1 if module number *t* is assigned to mission requirement *r* of mission *m*; 0 otherwise

- A binary decision variable, example: $X_{\_1\_3\_2}$
  - e.g., light equipment engineer module #1 assigned to the third mission requirement (repair) for mission #2 (airfield)

Define Set Notation

- Module Types (*J*)
  - The set of all types of infrastructure renewal (engineer) modules, e.g., route clearance, light horizontal construction, prime power, etc.
- Module (*T*)
  - *T(j)* = all modules of type $j \in J$
  - *t* is the module index number of a particular type of module *j* (e.g., prime power) out of the total number of modules available for a particular operation (e.g., OIF may only have four prime power modules available for use, or $|J(\text{primepower})| = 4$)
- Mission requirements (*R*)
  - Missions formed by coupling ‘Subsystem’ + ‘secondary assessment requirements’
  - The set of all mission requirements, e.g., water_pump_**secure**_req, water_pump__**assess**_req, water_pump_**repair**_req, etc.
  - *r* is the mission requirement index number, e.g., water_pump_secure_req is *r* = 1, water_pump_assess_req is *r* = 2, etc.
  - There is a direct linkage between mission requirements (e.g., airfield_repair_req) and module capabilities (e.g., a light horizontal construction module could perform ‘x’ number of units of airfield_repair_cap)
- Missions (*M*)
  - Is the set of all missions that are required to be performed, e.g., secure cultural site, assess road, repair airfield, etc.
  - *m* is the mission index number, e.g., secure cultural site would be *m* = 1, assess road would be *m = 2*, etc.

Additional Notation (1 of 2)

- x_{trm} = 1 if module number *t* is assigned to mission requirement *r* of mission *m*; 0 otherwise
  - A binary decision variable, example: $X_{\_1\_3\_2}$
  - e.g., light equipment engineer module #1 assigned to the third mission requirement (repair) for mission #2 (airfield)
- w_{tr} = Module work rate
  - Each module, $t \in T(j)$ has an identical work rate (w_{tr}) for a particular requirement *r*
  - Size of this table is an $|T|$ x $|R|$ matrix
- a_{tr} = An asset ratio
  - Defined as: volume of a module (i.e. amount of space that the equipment assigned to a module requires on board a ship or aircraft, in cubic feet)/ module work rate for the **Repair** requirement of a mission (w_{tr}); **Assess** requirements don't have ratios and the coefficient of a **secure** requirement is simply the volume of the module/ number of modules needed to secure the subsystem in question
  - If a particular module *t* of type *j* cannot satisfy a particular requirement, *r* (e.g. an area clearance module cannot satisfy any airfield repair requirements for any mission), then x_{trm} is fixed equal to 0 for all $m \in M$. This will prevent it from being selected to satisfy any mission requirement for which it cannot provide the requisite capability.
  - The objective function rewards smaller modules that do a larger amount of work (proportionally), i.e., a lower a_{tr} is considered to be better
  - This information yields an $|E|$ x $|R|$ matrix

Additional Notation (2 of 2)

- v_{rm} = Violation measure
  - A slack decision variable associated with requirements $r \in R$ and missions $m \in M$, that may assume any real, non-negative value.
  - It is assessed in the constraints if a particular capability (i.e. left-hand side, or technical coefficient value) cannot satisfy the right hand side values of the constraint.
- q_{rm} = Penalty associated with violating constraints
  - The penalty is (1 – criticality score for the subsystem component of the mission) decreases as the priority of the mission becomes less important. This relationship discourages any tendency to allocate resources to lower priority missions until higher priority mission resource requirements have been satisfied.
  - This information yields an $|R|$ x $|M|$ matrix
- Maximum and minimum violation measure
  - max_v_m = the maximum violation measure assessed for a particular mission. There will only be one per mission and it will be the greatest violation measure for any requirement within a particular set of mission constraints.
  - min_v_m = the minimum violation measure assessed for a particular mission. There will only be one per mission and it will be the smallest violation measure for any requirement within a particular set of mission constraints.

Objective Function

- Minimize

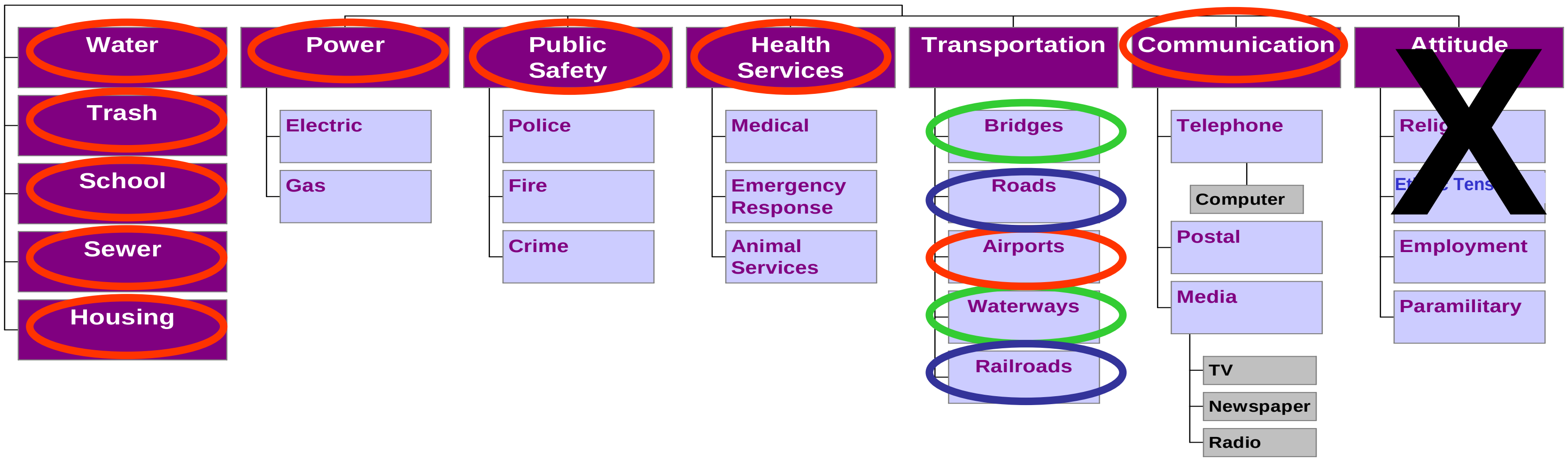
$$\sum_t \sum_r a_{tr} \sum_m x_{trm} + \sum_r \sum_m q_{rm} v_{rm} + \sum_m s_m (\mathrm{max\_v_m} - \mathrm{min\_v_m})$$

- There are four different types of constraints in this model:
  - Work requirement constraints
  - Module sharing constraints
  - Module redundancy constraints
  - Violation measure constraints

Recommended Future Research (1 of 2)

- Need to map infrastructure assessment categories (developed by NTC/ Engineer School) to nationally recognized 'standards'
  - *Defense Intelligence Agency (DIA) Gemini database (used by EI2RC)*
  - *National Strategy for the Physical Protection of Critical Infrastructures and Key Assets*
  - CRS Report for Congress, *Critical Infrastructure and Key Assets: Definition and Identification*, 1 October 2004.
- Also ensure that design of future system accounts for:
  - Joint interoperability requirements (e.g. Ensure we are talking to our Navy & Air Force counterparts, as well as other government agencies such as USAID and FEMA)
  - Automation architecture requirements (e.g. EI2RC driven by GIS data that is codified according to Defense Intelligence Agency (DIA) categories)

Engineer School "Infrastructure" Assessment Categories (Re-visited)



- At a minimum, need to add the following categories:

  1. Agriculture and food (include all aspects of food supply chain (e.g. from farmer's field to grocery store)).
  2. Cultural and historical (include places of worship).
  3. Chemical industry and hazardous materials.

- Remove 'attitude' as a separate category. However, still vital to assess vis-à-vis the larger infrastructure assessment.
- Ensure that a structural assessment (or analysis) of each sub-system is part of the overall assessment package → But not a separate infrastructure category.
- Subject to criteria on previous slide, total of 15 categories (or systems) to be incorporated into EI2RC and other automation support tools.

Recommended Future Research (2 of 2)

- Further develop and codify engineer module capabilities (work already initiated by Director of Combat Developments (DCD) Engineer School in FY03-04)
  - Incorporate into database for use by the optimization model;
  - Ensure engineer module capabilities can be mapped to the infrastructure (engineer) mission requirements from the two previous slides.
- Ensure prevalent engineer automation tools (e.g. TCMS, PCASE, Survivability Tool) all use a common language when defining engineer [module] capabilities
- Use similar methodology to aggregate:
  - Over multiple locations;
  - To quantify and quickly provide commander's snapshot (e.g. Black, Red, Amber, or Green status about a particular subsystem at a particular location).
- Determine viable architecture/ interface for IA tool:
  - Excel with solver → Flat file db only; Solver not powerful enough;
  - Access → Adequate for data management; Solver?;
  - Php/MySQL → Allows for web interface with a professional grade database
    - For solver: webCOIN or industry standard (e.g. CPLEX).
- Ensure that we integrate infrastructure assessment planning into warfighter's decision-making cycle

Summary

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  - Bottom Line Up Front (BLUF)
  - Problem Definition Phase
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- Methodology
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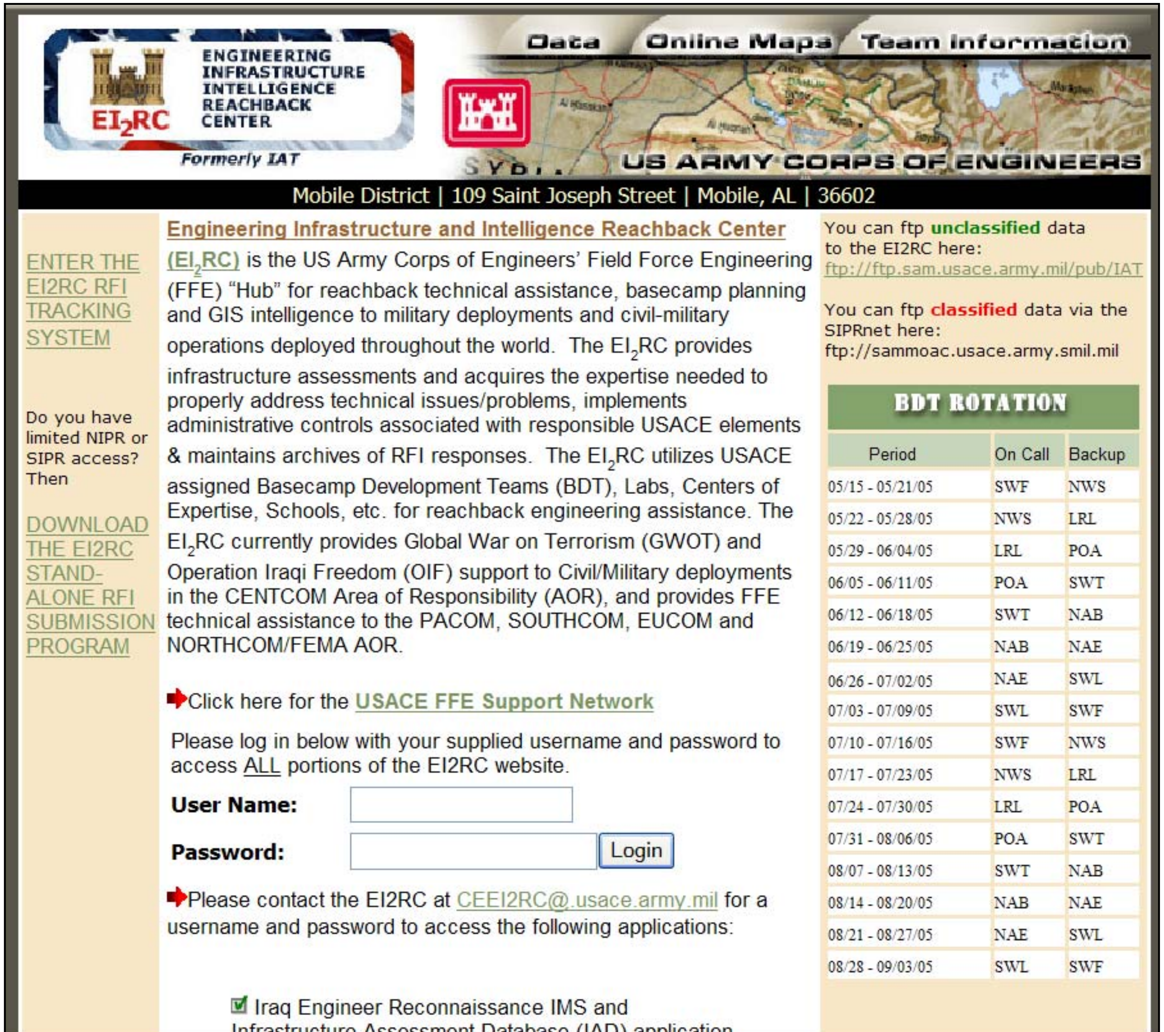
Questions

?

Backup – EI2RC Overview



ENGINEERING INFRASTRUCTURE INTELLIGENCE REACHBACK CENTER

EI_2RC

Formerly IAT

Data | Online Maps | Team Information

US ARMY CORPS OF ENGINEERS

Mobile District | 109 Saint Joseph Street | Mobile, AL | 36602

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You can ftp **classified** data via the SIPRnet here: ftp://sammoac.usace.army.smil.mil

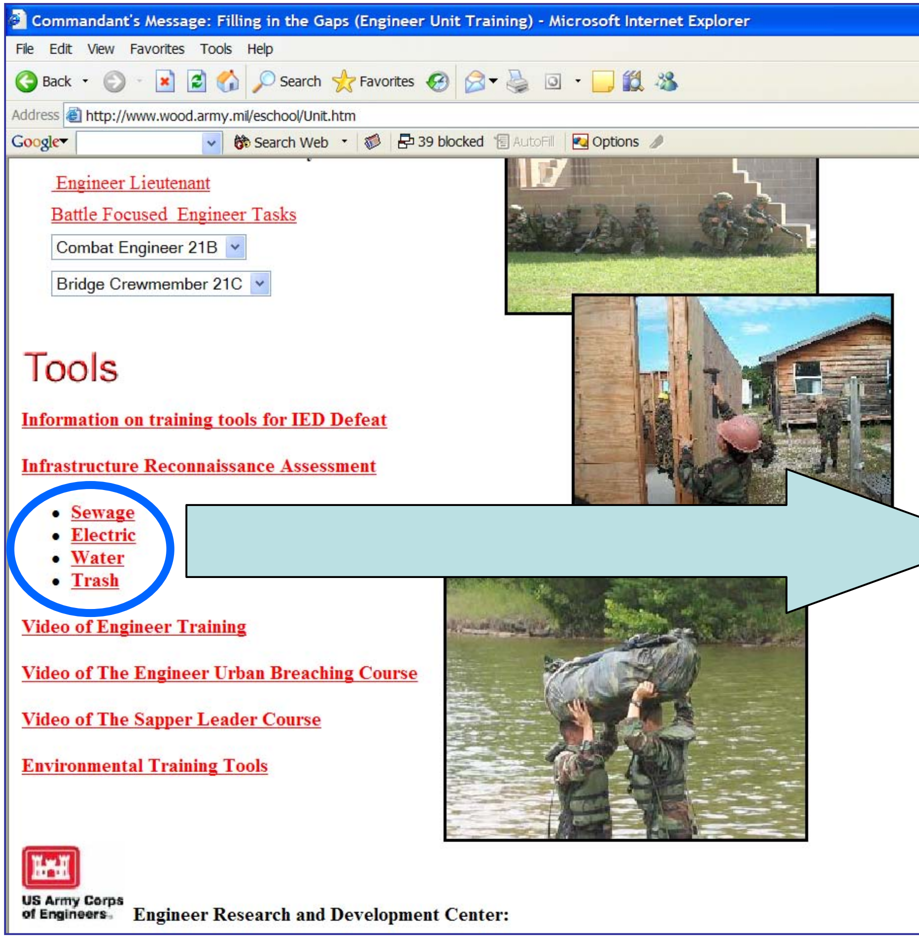
BDT ROTATION

Period	On Call	Backup
05/15 - 05/21/05	SWF	NWS
05/22 - 05/28/05	NWS	LRL
05/29 - 06/04/05	LRL	POA
06/05 - 06/11/05	POA	SWT
06/12 - 06/18/05	SWT	NAB
06/19 - 06/25/05	NAB	NAE
06/26 - 07/02/05	NAE	SWL
07/03 - 07/09/05	SWL	SWF
07/10 - 07/16/05	SWF	NWS
07/17 - 07/23/05	NWS	LRL
07/24 - 07/30/05	LRL	POA
07/31 - 08/06/05	POA	SWT
08/07 - 08/13/05	SWT	NAB
08/14 - 08/20/05	NAB	NAE
08/21 - 08/27/05	NAE	SWL
08/28 - 09/03/05	SWL	SWF

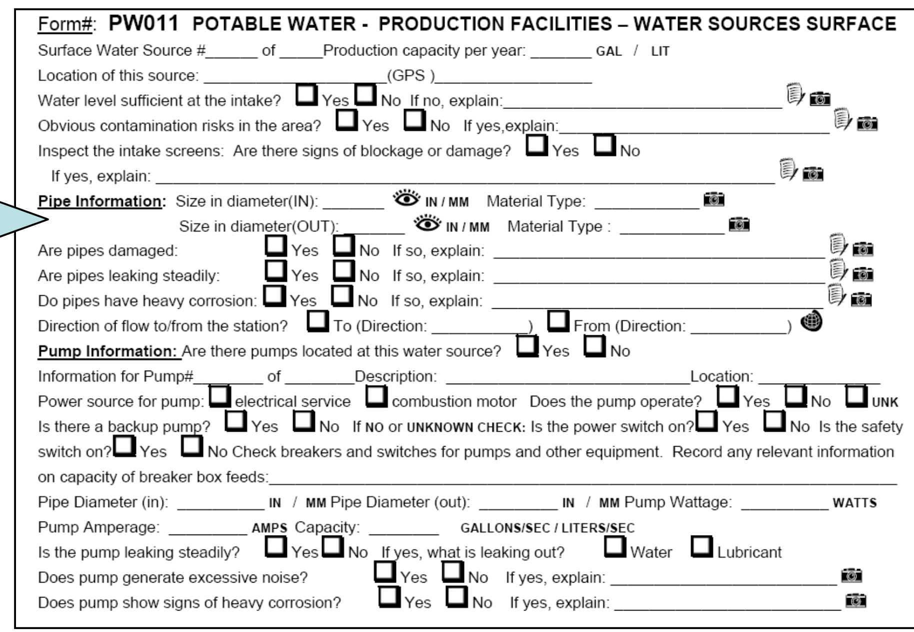
http://gis.sam.usace.army.mil/iat.asp

Backup – Infrastructure Checklists

http://www.wood.army.mil/eschool/Unit.htm



Each .pdf file provides a description, overview of the particular category, followed by the checklists, the information from which are used to populate the EI2RC Database.



Form#: **PW011 POTABLE WATER - PRODUCTION FACILITIES – WATER SOURCES SURFACE**

Surface Water Source #______ of _____Production capacity per year: _______ GAL / LIT

Location of this source: _____________________(GPS)_________________

Water level sufficient at the intake? ☐ Yes ☐ No If no, explain:________________________________

Obvious contamination risks in the area? ☐ Yes ☐ No If yes,explain:_______________________________

Inspect the intake screens: Are there signs of blockage or damage? ☐ Yes ☐ No

If yes, explain: ____

Pipe Information: Size in diameter(IN): _______ IN / MM Material Type: ____________

Size in diameter(OUT):_______ IN / MM Material Type : ____________

Are pipes damaged: ☐ Yes ☐ No If so, explain: ____________________________________

Are pipes leaking steadily: ☐ Yes ☐ No If so, explain: ____________________________________

Do pipes have heavy corrosion: ☐ Yes ☐ No If so, explain: ____________________________________

Direction of flow to/from the station? ☐ To (Direction: ___________) ☐ From (Direction: ___________)

Pump Information: Are there pumps located at this water source? ☐ Yes ☐ No

Information for Pump#_______ of _______Description: __________________________Location: _____________

Power source for pump: ☐ electrical service ☐ combustion motor Does the pump operate? ☐ Yes ☐ No ☐ UNK

Is there a backup pump? ☐ Yes ☐ No If NO or UNKNOWN CHECK: Is the power switch on? ☐ Yes ☐ No Is the safety switch on? ☐ Yes ☐ No Check breakers and switches for pumps and other equipment. Record any relevant information on capacity of breaker box feeds:____

Pipe Diameter (in): __________ IN / MM Pipe Diameter (out): __________ IN / MM Pump Wattage: __________ WATTS

Pump Amperage: _________ AMPS Capacity: ________ GALLONS/SEC / LITERS/SEC

Is the pump leaking steadily? ☐ Yes ☐ No If yes, what is leaking out? ☐ Water ☐ Lubricant

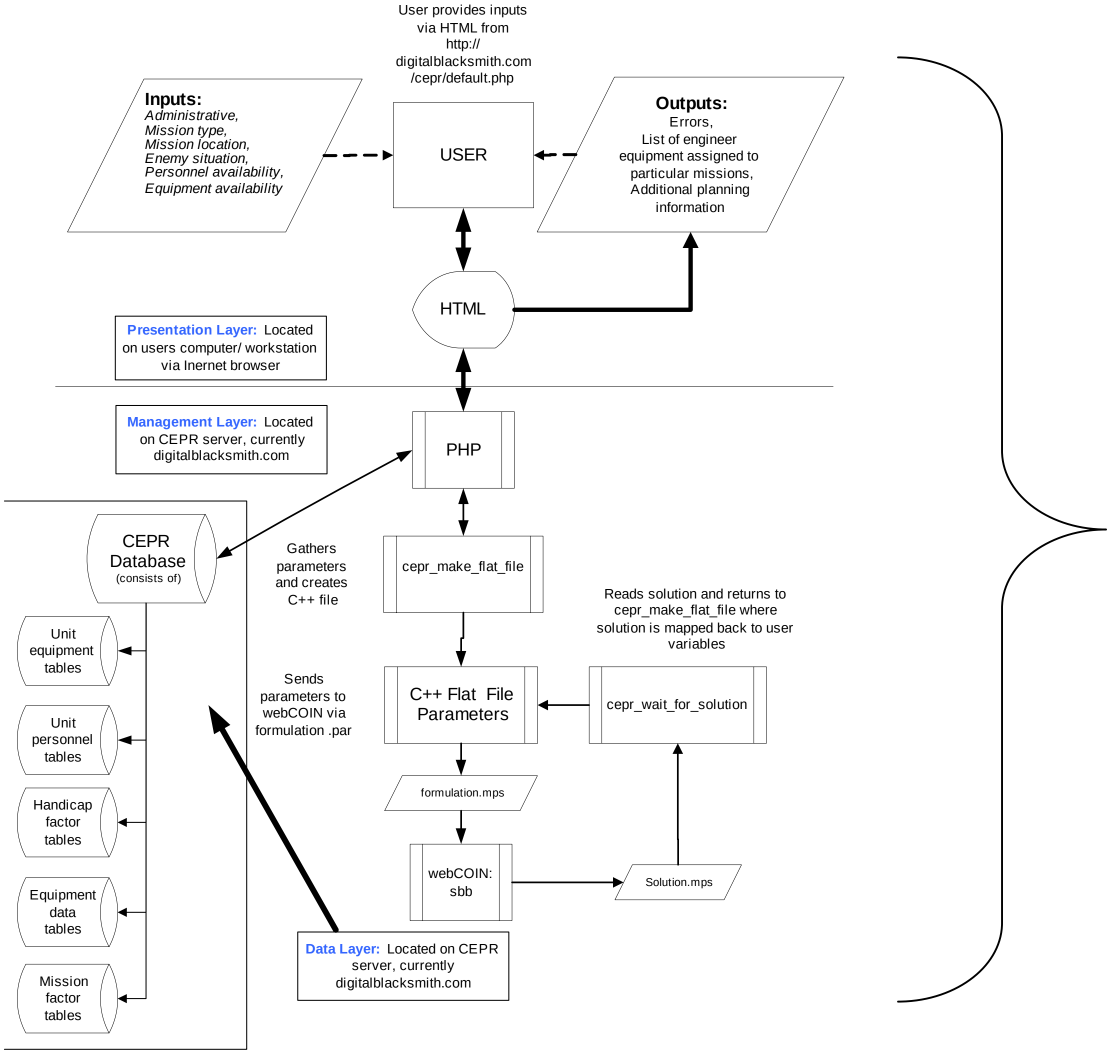
Does pump generate excessive noise? ☐ Yes ☐ No If yes, explain: ______________________________

Does pump show signs of heavy corrosion? ☐ Yes ☐ No If yes, explain: ______________________________

Backup – Secondary Assessment (Overview)

- Criticality scores provide overall assessment of the importance of an infrastructure subsystem
- What about more refined concerns *(Use same data, just adjust weights of performance measures)*?
  - Which assets should I **secure** first?
    - Population served *(Higher is more critical)*
    - Cost to repair or replace *(Higher is more critical)*
    - Number of identical (or nearly identical) subsystems currently available to perform same (or very similar) level of service at the same location *(Less is better)*
    - # of other subsystems 'immediately' dependent on this subsystem to operate properly *(Higher is more critical)*
  - Which assets should I **assess** first?
    - Population served *(Higher is more critical)*
    - Cost to repair or replace *(Higher is more critical)*
    - Amount of time needed to repair or replace *(Higher is more critical)*
    - Current "perceived" degradation in level of service (% change from 'original' LOS) *(Higher is more critical)*
    - Number of U.S. or coalition personnel needed to secure until operational or until host nation can provide adequate security *(Higher is more critical)*
    - Number of identical (or nearly identical) subsystems currently available to perform same (or very similar) level of service at the same location *(Less is better)*
    - # of other subsystems 'immediately' dependent on this subsystem to operate properly *(Higher is more critical)*
  - Which assets should I **repair or rebuild** first? *(This prioritization technique uses a different 'priority rule' than initial assessment method?)*
    - Population served *(Higher is more critical)*
    - Amount of time needed to repair or replace *(Higher is more critical)*
    - Current "perceived" degradation in level of service (% change from 'original' LOS) *(Higher is more critical)*
    - Number of U.S. or coalition personnel needed to secure until operational or until host nation can provide adequate security *(Higher is more critical)*
    - Number of identical (or nearly identical) subsystems currently available to perform same (or very similar) level of service at the same location *(Less is better)*
    - # of other subsystems 'immediately' dependent on this subsystem to operate properly *(Higher is more critical)*

Backup – Proposed Implementation Plan



While this proposed architecture was designed for CEPR (i.e. TJ Lindberg's thesis…), it can easily be modified to perform infrastructure assessment.

References

- Ahuja, Ravindra K., Thomas L. Magnanti, and James B. Orlin. Network Flows: Theory, Algorithms, and Applications, Prentice Hall, 1993.
- Albright, S. Christian. VBA for Modelers: developing Decision Support Systems with Microsoft Excel, Duxbury, 2001.
- Ashparie, et. al. (George Mason University) *Infrastructure Analysis System*, presentation given at USMA's Department of Systems Engineering Capstone Conference, 4 May 2005.
- Clemen, Robert T. and Terrence Reilly. Making Hard Decisions, with Decision Tools, Duxbury, 2001.
- CRS Report for Congress, *Critical Infrastructure and Key Assets: Definition and Identification*, 1 October 2004. http://www.fas.org/sgp/crs/RL32631.pdf
- Hardegree, Lynn, Lynn.C.Hardegree@sam.usace.army.mil Engineering Infrastructure Intelligence Reachback Center (EI2RC), Mobile District, U.S. Army Corps of Engineers (USACE)
- Kirkwood, Craig W. Strategic Decision Making: Multiobjective Decision Analysis with Spreadsheets, Duxbury, 1997.
- International Journal of Critical Infrastructure http://inderscience.metapress.com/link.asp?id=110843
- Manous, COL Joseph, et. al. *Infrastructure Information and Data Collection (I2DC), May 2005.*
- National Strategy for the Physical Protection of Critical Infrastructures and Key Assets http://www.whitehouse.gov/pcipb/physical.html
- SWEAT Assessment presentation and numerous tools, Engineer Observer-Controller Team (Sidewinders), National Training Center Operations Group.
- Trainor, LTC Timothy E. PhD and Dr. Gregory Parnell. *USMA Study of the Installation Management Agency CONUS Region Structure*, November 2004.
- Wilson, G.I., Greg Wilcox, and Chet Richards, *Fourth Generation Warfare & OODA Loop Implications of The Iraqi Insurgency* (Powerpoint Presentation), December 2004.

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